NETWORK SUPPORT FOR SUBSCRIBER ACCESS TO MOBILE CALLER LOCATION INFORMATION

BACKGROUND OF THE INVENTION

The present invention is directed to the art of providing information about calling parties to called parties. More particularly, the present invention is directed to systems and methods for providing location information regarding a calling party to the called party where the calling party is using mobile user equipment such as a mobile or cellular phone, personal digital assistant (PDA) or other device.

In the United States, the Federal Communications Commission (FCC) is requiring wireless carriers to be able to locate users on their network when they make a 911 emergency call. Regulations in this area are referred to generally as Enhanced 911 or E911. As a result, various user locating technologies have been, and are being, implemented in wireless communications networks.

For example, some user equipment, such as, mobile phones and personal digital assistance (PDAs) include global positioning system receivers and can provide GPS coordinates of the user equipment to the mobile network over which they communicate. Other locating systems do not rely on GPS technology.

Instead, cellular triangulation techniques are used. Some cellular triangulation techniques measure the signal strength of the target piece of user equipment at, for example, three or more cell sites, and use those measurements to determine a distance to the user equipment from each of the cell sites. Other cellular triangulation techniques are based on a measurement of time delays of signals transmitted from the user equipment to the plurality of cell sites. The time delays are used to calculate distances. Additionally, or alternatively cellular triangulation can include the use of directional antennas. By rotating a directional antenna and monitoring the strength of signals from the user equipment an antenna orientation associated with a strongest or weakest signal strength can be determined. That antenna orientation is associated with a direction to the user equipment. By projecting vectors from two or more cell sites toward the user equipment an intersection of the vectors can be found. The intersection of the vectors is the location of the user equipment.

Location information regarding calling parties can be useful in situations beyond the 911 emergency call scenario. For example, where lost travelers call someone at their desired destination in order to receive new or updated directions, it can be useful to provide the called party with accurate location information regarding the lost travelers so that specific and customized directions can be provided. Caller location information can also be useful where there is a need or desire to verify the location of the calling party. For example, parents may want to verify the location of their children. Dispatchers may want to verify or accurately determine the location of security or delivery personnel. Parole officers can use location information to determine whether or not parolees checking in by phone are within prescribed boundaries.

Therefore, there is a desire to provide location information regarding calling parties to called parties on a more general basis than is currently available.

SUMMARY OF THE INVENTION

A method operative to include caller location information in information made available to user equipment of a called party includes receiving a call request from the calling party, extracting called party identification information from the call request, determining that the called party subscribes to a caller location service based on the extracted called party identification information, determining a latitude and longitude of the calling party, determining a common description of a location of the calling party based on the latitude and longitude, including the common description of the location of the calling party in a message, and transmitting the message to the user equipment of the called party.

Determining that the called party subscribes to a caller location service can include accessing user subscription information of a subscriber database of the called party.

Determining a latitude and longitude of the calling party can include determining that the user equipment of the calling party includes a GPS receiver and requesting GPS coordinates from the user equipment of the calling party. Alternatively, determining a latitude and longitude of the calling party can include requesting coordinates of the calling party user equipment be determined by cellular triangulation.

Determining a common description of a location of the calling party can include receiving GPS coordinates and using the GPS coordinates as an index into a common location description database to determine at least one of an address, a city name, and a distance and heading from a landmark. Alternatively, determining a common description of a location of the calling party can include receiving coordinates based on cellular triangulation

and using the coordinates as an index into a common location description database to determine at least one of an address, a city name, and a distance and heading from a landmark.

Where providing location information of a calling party is an optional service, the method can include verifying that the calling party is included in a list of potential calling parties for which the called party desires location information.

Some embodiments include a method operative to provide caller location information to user equipment of a called party. The method includes receiving a call request from the calling party, extracting called party identification information from the call request, determining that the called party subscribes to a caller location service based on the extracted called party identification information, determining if the user equipment of the calling party is GPS enabled, requesting GPS coordinates from the user equipment of the calling party if the user equipment of the calling party is GPS enabled, requesting cellular triangulation services be used to generate location information regarding the user equipment of the calling party if the user equipment of the calling party is not GPS enabled, determining a common description of a location of the calling party based the GPS coordinates or the generated location information, including a representation of the common description of the location in a caller ID field of a message, and transmitting the message to the user equipment of the called party.

Some of those embodiments include extracting calling party user equipment identification information from the call request, retrieving a list of potential calling party user equipment for which the called party desires location information, comparing the extracted calling party user equipment identification information to entries in the list of potential calling party user equipment, and determining that one of the entries in the list matches the extracted calling party user equipment identification information.

Determining that the called party subscribes to a caller location service based on the extracted called party identification information can include querying a subscriber database associated with the called party, and retrieving location feature subscription information regarding the called party.

Determining if the user equipment of the calling party is GPS enabled can include extracting calling party user equipment identification information from the call request, retrieving a list of potential calling party user equipment for which the called party desires location information, the list including GPS enablement status information regarding the potential calling party user equipment. Alternatively, determining if the user equipment of the

calling party is GPS enabled can include sending a GPS enablement query message to the user equipment of the calling party.

Requesting cellular triangulation services can include transmitting a plurality of Pilot Strength Measurement (PSM) data collection messages to a respective plurality of cell sites within range of the user equipment of the calling party.

A system operative to include caller location information in information made available to user equipment of a called party includes means for receiving a call request from the calling party, means for extracting called party identification information from the call request, means for determining that the called party subscribes to a caller location service based on the extracted called party identification information, means for determining a latitude and longitude of the calling party, means for determining a common description of a location of the calling party based on the latitude and longitude, means for including the common description of the location of the calling party in a message, and means for transmitting the message including the appended common description of the location to the user equipment of the called party.

Some embodiments also include means for transmitting a first PSMM_Request message from a first cell site to the user equipment of the calling party, means for transmitting a first response to the first PSM message, means for determining a first delay from the first response, means for transmitting a second PSMM_Request message from a second cell site to the user equipment of the calling party, means for transmitting a second response to the second PSM message, means for determining a second delay from the second response, means for transmitting a third PSMM_Request message from a third cell site to the user equipment of the calling party, means for transmitting a third response to the third PSM message, means for determining a third delay from the third response, and means for determining a relative position of the user equipment of the calling party to the first, second and third cell sites based on the first, second and third delays.

Some embodiments include means for transmitting a plurality of PSMM_Request messages from a plurality of cell sites to the user equipment of the calling party, means for transmitting a plurality of responses to the plurality of PSM messages, means for determining a plurality of delays from the plurality of responses, and means for determining a relative position of the user equipment of the calling party to the plurality of cell sites from the plurality of delays.

Additionally, some embodiments include means for calculating an absolute position of the user equipment of the calling party from the relative position of the user equipment and known positions of the first second and third cell sites.

Where providing location information of a calling party is an optional service, embodiments can include means for verifying that the calling party is included in a list of potential calling parties for which the called party desires location information.

Some systems include a mobile switching center operative to provide calling party location information to user equipment of a called party. The mobile switching center includes a coordinate determiner operative to determine geographic coordinates of user equipment of a calling party, a coordinate converter operative to determine a common description of a geographic location associated with the geographic coordinates determined by the coordinate determiner, and a network interface operative to transmit the common description to the user equipment of the called party.

For example, the coordinate determiner can include a GPS coordinate determiner operative to send a request for GPS coordinates to the user equipment of the calling party and receive GPS coordinates from the user equipment of the calling party. Additionally, or alternatively, the coordinate determiner can include a cellular triangulator operative to coordinate the collection of measurements associated with the user equipment of the calling party and the calculation of geographic coordinates associated with the location of the user equipment of the calling party based on the collected measurements. Some cellular triangulators are operative to collect the measurements associated with the user equipment through the transmission of a plurality of PSM messages.

DESCRIPTION OF THE DRAWINGS

The invention may take form in various components and arrangements of components, and/or in various procedures and arrangements of procedures. The drawings are only for purposes of illustrating preferred embodiments. They are not to scale, and are not to be construed as limiting the invention.

FIG. 1 is a flow chart outlining a method for providing location information regarding mobile user equipment of a calling party to user equipment of a called party.

FIG. 2 is a call flow diagram outlining aspects of an embodiment of the method of FIG. 1 where the user equipment of the calling party includes a GPS receiver.

FIG. 3 is a call flow diagram outlining aspects of an embodiment of the method of FIG. 1 where the user equipment of the calling party is not GPS enabled.

FIG. 4 is a block diagram of a system for providing location information regarding mobile user equipment of a calling party to user equipment of a called party.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a method **110** for providing caller location information to user equipment of a called party begins with the reception on **114** of a call request. If caller location information is to be provided only under certain circumstances, tests may be performed to determine if the circumstances are met. For example, called party and calling party identification information may be extracted **118** from the received call request. A determination **122** can be made as to whether the called party subscribes to a caller location service. If the called party does subscribe to a location service a determination **126** can be made as to whether the called party desires location information for the calling party. If **122** the called party does not subscribe to the location service or if **126** the called party does subscribe to a location service but does not subscribe to location information for the calling party, the call is processed **130** without further concern for location information.

If a determination **122, 126** is made, that location information is to be provided to the called party. The method **110** includes determining a location of the calling party. For example, a determination **134** is made as to whether or not user equipment of the calling party includes Global Positioning (GPS) equipment. If **134** the user equipment of the calling party does include a GPS receiver, a request **138** is made of the user equipment for the current GPS coordinates of the user equipment. If the user equipment of the calling party does not include a GPS receiver, a request **142** is made for cellular triangulation of the calling parties user equipment. By one method or another, location information or coordinates regarding the calling party or the user equipment of the calling party is received **146**.

The received coordinates are converted **150** into a more common location description. The common location description, or some representation or abbreviation thereof is then transmitted **154** to the user equipment of the called party. For example, a street address, a city name, or other location description or an abbreviation therefore is included in a caller ID field of a message transmitted to the user equipment of the called party. The user equipment of the called party may then display, read via voice synthesis, log or otherwise process the location description as desired by the called party.

Extracting **118** called and/or calling party identification information can include for example extracting caller ID information to identify the calling party. The directory number of the called party can act as an identifier of the called party. Additionally, or alternatively,

other identifiers can be used, such as, for example, Mobile Identification Numbers or Electronic Serial Numbers.

The called party identification information can be used to determine **122** whether or not the called party subscribes to the location service. For instance, a directory number of the called party can be used as an index into a subscriber database containing subscriber service subscription information. For example, the subscription information of the called party may indicate that location information is desired for everyone that calls the called party. Alternatively, the subscriber database may include a list of specific individuals or specific user equipment for which location information is desired. For example, the list may include a plurality of directory numbers, Mobile Identification Numbers (MINs) and/or Electronic Serial Numbers (ESNs) for which location information is to be collected. The extracted **118** calling party identification information can be compared to the listed party or user equipment identification information to make the determination **126** as to whether the called party desires location information with regard to the calling party. For instance, parents may only be interested and therefore may only subscribe for location information with regard to their children or the cell phones of their children. A delivery service may only list user equipment associated with delivery vehicles or delivery personnel.

The location or coordinate information received **146** may be in any convenient format. For example, location information may be received **146** in the form of latitude and longitude. If necessary, conversion **150** of the location information may be performed by network elements. For example, a Mobile Switching Center (MSC) or visitor location/home location register (VLR/HLR) may house a location look-up database including, for example, common descriptors such as addresses, street names, city names and/or landmark names for a geographic area local to the Mobile Switching Center. Alternatively, a more central location look-up database can include common location descriptors for a much wider area, such as, for example, an entire state, country, continent or for the whole world. Independent of the database configuration or dissemination, the received **146** location information is used as an index or key into an appropriate location look-up database to determine or retrieve the common descriptor for the location of the user equipment of the calling party.

The common location description can then be transmitted **154** to the user equipment of the called party. For example, the location descriptor may be appended to, or included instead of, the caller ID information.

For example, referring to FIG. 2, in a first scenario, a calling party places a call using mobile user equipment **210** such as a cellular phone or personal digital assistant. The user

equipment **210** issues a mobile origination message **214** to a serving cell site **218**. The cell site **218** relays content of the mobile origination message **222** to a Mobile Switching Center **226**. The Mobile Switching Center (MSC) **226** receives **114** the origination call message or request **222** and extracts **118** called and calling party identification information from the call request **222**. The Mobile Switching Center **226** sends appropriate messages **230** to a subscriber database **234**. The subscriber database **234** is included, for example, in a Visitor Location Register/Home Location Register (VLR/HLR). For instance, the message **230** requests the state of a location display feature activation bit associated with the called party identification information. Additionally, the message **230** requests a list of directory numbers or other calling party identifiers for which the called party desires location information. The subscriber database **234** responds with a message **238** including the state of the location display feature activation bit and, if applicable, the list of devices for which the called party desires location information. The MSC **226** examines the information contained in the response **238** to determine **122** if the call party subscribes to the location display feature and if the called party does subscribe to the feature determines **126** if the mobile user equipment **210** of the called party is included in the list of devices for which the called party desires location information.

If identification information associated with the mobile device **210** is included in the list of devices for which location information is desired, the MSC **226** determines **134** whether or not the mobile device **210** can provide GPS location information. For example, the MSC **226** sends a GPS enable inquiry message **242** to the subscriber database **234** in association with identification information associated with the mobile user equipment **210**. For instance, the GPS enable inquiry **242** includes a directory number, an MIN and/or ESN of the mobile device **210**. Alternatively, information regarding whether or not the mobile devices are GPS enabled is included in the list provided in the response message **238**. In a further alternative, the GPS inquiry is sent to the mobile user equipment **210**.

In any event, if the mobile user equipment **210** is GPS enabled, an indication **246** thereof is sent to the MSC **226**. In that case, the MSC **226** requests **138** current GPS coordinates from the mobile user equipment **210**. For example, the MSC **226** sends a GPS location request message **250** to the serving cell site **218**. The cell site **218** relays the location request **250** to the mobile device **210**. The mobile device **210** transmits a GPS location response message **254** including, for example, latitude and longitude coordinates to the cell site **218**. The cell site **218** relays the location response **254** to the MSC **226**. The MSC **226** may then send a location conversion request message **258** to a common location description

look-up database **262**. For example, the location look-up database **262** may also be housed in a VLR/HLR. Alternatively, the location look-up database **262** is local to the MSC **226** or is part of a remote network adjunct. The location look-up database **262** provides a common description for the location associated with the coordinates received in the location response message **254**. For example, the location look-up database **262** transmits a location identifier message **266** including a city name, state name, street address, nearest intersection, distance and direction from a landmark or an abbreviation therefore. The MSC then includes the common location description when an MSC_Network Origination message **270** is sent via a communications network **274** to the user equipment of the called party. For example, the common location description is included in a caller ID field of the MSC_Network Origination message **270** either in addition to or in place of the standard caller ID information.

Referring to FIG. 3, if a calling party uses mobile user equipment **310** that is not GPS enabled, the call processing proceeds in a manner similar to that described in reference to FIG. 2 up to the point the MSC **226** attempts to determine **134** whether or not the mobile device **310** can provide GPS coordinates. Instead of receiving an indication **246** that the device is GPS enabled, the MSC **226** receives an indication **346** that the mobile device **310** is not GPS enabled. The MSC **226** then attempts to retrieve location information regarding mobile device **310** by some other means. For example, the MSC initiates a cellular triangulation procedure.

For instance, the MSC **226** uses the serving cell site **218** as a reference cell site. The MSC **226** identifies a plurality of additional cell sites e.g. **350**, **354** neighboring the reference cell site **218**. For instance, the MSC **226** identifies from 2 to about 5 additional cell sites in the vicinity of the mobile user equipment **310** of the calling party. The MSC **226** sends a plurality of Pilot Strength Measurement (PSM) data collection messages e.g. **358**, **360**, **362** to the cell sites e.g. **218**, **350**, **354** in the vicinity of the mobile device **310**. In turn, the cell sites send Pilot Strength Measurement data collection messages (e.g. **364**, **366**, **368)** to the mobile device **310.** The mobile device **310** replies to each PSM data collection message (e.g. **364**, **366**, **368)** with a PSM response message **370**, **372**, **374**. Each of the plurality of cell sites e.g. **350**, **354** and the reference site **218** relay the response messages **370**, **372**, **374** to the MSC **226**. The MSC **226** uses signal strength or message delay parameter values associated with the response messages **370**, **372**, **374** to calculate a position of the mobile device **310** relative to the cell sites (e.g. **218**, **350**, **354)**. This relative position is combined with absolute positions of the cell sites (e.g. **218**, **350**, **354)** available to the MSC **226** in order to determine

an absolute position of the mobile device **310**. Then, in a manner similar to that described in reference to FIG. 2, the calculated absolute position of the mobile device **310** can be included in a common location description request message **378** sent by the MSC **226** to the common location description look-up database **262**. The calculated location coordinates included in the common location description request message **378** may be in a different format than used in the GPS based common location description request message **258** mentioned in reference to FIG. 2.

As described in reference to FIG. 2, the location look-up database **262** responds to the MSC **226** with the location identifier message **266** including some common description of the location of the mobile device **310** and the MSC **226** includes that description in an MSC_Network Origination message sent via the network **274** to the user equipment of the called party.

The procedures of the method **110** can be performed by a wide variety of network elements. The responsibility for carrying out the procedures of the method can be distributed among a variety of network elements or implemented in a more concentrated fashion by various combinations of hardware and software.

Referring to FIG. 4, in one implementation, a mobile switching center **414** includes a subscription feature determiner **418**, a GPS coordinate determiner **422**, a cellular triangulator **426**, and a coordinate converter **430**. Of course, the mobile switching center **414** also includes main MSC functions **434** as are known in the art, and the MSC **414** includes a network interface **438** for communicating with a network **442** for carrying out the main MSC functions **434** and functions **422**, **418**, **430**, **426** of the method **110**.

The subscription feature determiner **418** may determine **122** if a called party subscribes to a location service and if so may determine **126** if the called party desires location information for a particular calling party. For example, the subscription feature determiner **418** may generate the appropriate messages **230** for retrieving a location feature activation bit and if applicable a list of parties or user equipment for which location information is desired. For instance, the subscription feature determiner **418** communicates with the subscriber database **234** by sending the appropriate messages **230** through the network interface **438** and through the network **442** to the subscriber database **234**. Information from the subscriber database **234** is delivered to the subscription feature determiner **418** through the network **442** and the network interface **438**. The subscription feature determiner **418** may analyze the list of user equipment to determine if the user

equipment of the calling party is GPS enabled. The results of such a determination are communicated to the GPS coordinate determiner **422** and/or the cellular triangulator **426**.

If the subscription feature determiner **418** informs the GPS determiner **422** that the user equipment of a calling party is GPS enabled (e.g. **210**) the GPS coordinate determiner **422** generates and transmits a GPS location request message **250**. The GPS location request message **250** is transmitted to the user equipment (e.g. **210**) of the calling party through the services of the network interface **438**, the network **442** and a serving cell site (e.g. **218**).

Alternatively, if the description feature determiner **418** does not provide an indication as to whether or not the user equipment of the calling party is GPS enabled the GPS coordinate determiner **422** may generate a query **242** as to whether or not the user equipment of the calling party can provide GPS coordinates. The GPS query **242** may be transmitted to the subscriber database **234** through the network interface and intervening network **442**. Alternatively, the GPS query **242** may be directed to the user equipment of the calling party. (e.g. **210**, **310**) via the network interface **438**, network **442** and a serving base station (e.g. **218**). If a response to the query indicates that the user equipment of the calling party is GPS enabled, the GPS coordinate determiner **422** generates and transmits a GPS location request message **250** as described above. If no response is received or if the response indicates that the user equipment of the calling party is not GPS enabled, the GPS coordinate determiner **422** so informs the cellular triangulator **426**.

When informed that location information of the calling party is desired but that GPS coordinates are unavailable, the cellular triangulator **426** coordinates the collection of locating information with regard to the user equipment (e.g. **310**) of the calling party. For example, the cellular triangulator **426** generates and coordinates the transmission of a plurality of PSM data collection messages **358**, **360**, **362**, **364**, **366**, **368**. For instance, the cellular triangulator **426** accesses knowledge **446** of the mobile network to determine a location of the serving cell site **218** and the identity and location of a plurality of neighboring cells sites (e.g. **350**, **354**) that may be in range of the user equipment of the calling party (e.g. **310**) for which location information is desired. The cellular triangulator **426** then initiates the transmission of the PSM data collection messages **358**, **360**, **362** to the serving cell site **218** in the plurality of neighboring cell sites **350**, **354**, respectively. In turn, the cell sites **218**, **350**, **354** transmit PSM data collection messages **364**, **366**, **368** to the user equipment of the calling party (e.g. **310**). The user equipment responds to each PSM data collection message **364**, **366**, **368** with a PSM response message **370**, **372**, **374**. Those messages **370**, **372**, **374** are relayed by the cell sites **218**, **350**, **354** to the cellular triangulator **426** through the services of

the network **442** and network interface **438**. The cellular triangulator **426** then uses information contained in the PSM response messages **370, 372, 374** and knowledge **446** about the locations of the cell sites **218, 350, 354** to determine a location of the user equipment of the calling party (e.g. **310**). For example, the cellular triangulator **426** uses message delay information and/or signal strength information contained within the PSM response messages **370, 372, 374** to determine a relative position of the user equipment of the calling party to the cell sites **218, 350, 354**. The cellular triangulator **426** combines that calculated relative position with the knowledge **446** available with regard to the absolute positions of the cell sites **218, 350, 354** to determine an absolute position or coordinates of the user equipment (e.g. **310**) of the calling party.

Coordinate information, whether collected from a GPS location response message **254** received by the GPS coordinate determiner **422** or generated through cellular triangulation by the cellular triangulator **426** may be delivered to the coordinate converter **430**. If so, the coordinate converter **430** generates a coordinate conversion message **258, 378** and transmits the coordinate conversion message **258, 378** to the common location description look-up database **262** through the services of the network interface **438** and the intervening network **442**. The location look-up database **262** responds with a common description or location identifier **266** related to the position of the user equipment (e.g. **310**) of the calling party. The location identifier **266** is transmitted to the coordinate converter **430** through the services of the network **442** and the network interface **438**. The coordinate converter **430** generates an MSC_Network Origination message **270** and transmits the MSC_Network Origination message **270** to user equipment **450** of the called party. Again, the message **270** is transmitted through the services of the network interface **438** and the intervening network **442**. The MSC_Network Origination message **270** includes the common description of the location of the calling party. For example, the location description is appended to or replaces caller ID information. The user equipment **450** of the called party may be a mobile or wired device. The location information may be displayed before the call is answered, may be communicated to the called party when the call is answered or at some point during the conversation, and/or may be logged for future reference. Alternatively, unconverted coordinate information may be included in the MSC_Network Origination message.

The invention has been described with reference to preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the present specification. It is intended that the invention be construed as including all such

modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.